PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :
G06F 17/30

A1

(11) International Publication Number: WO 99/22316

(43) International Publication Date: 6 May 1999 (06.05.99)

(21) International Application Number: PCT/US98/21008

(22) International Filing Date: 2 October 1998 (02.10.98)

(30) Priority Data:
08/959,313 28 October 1997 (28.10.97) US

(71) Applicant: CACHEFLOW, INC. [US/US]; 650 Almanor Avenue, Sunnyvale, CA 94086 (US).

(72) Inventors: CROW, Doug; 24, 133 S.E. 45th Place, Issaquah, WA 98029 (US). BONKOWSKI, Bert; 345 Coleridge Drive, Waterloo, Ontario N2L 3E6 (CA). CZEGLEDI, Harold; 199 Ironwood Place, Waterloo, Ontario N2T 2L4 (CA). JENKS, Tim; 5636 42nd Avenue, S.W., Seattle, WA 98136 (US).

(74) Agent: SWERNOFSKY, Steven, A.; The Law Offices of Steven A. Swernofsky, P.O. Box 390013, Mountain View, CA 94039-0013 (US).

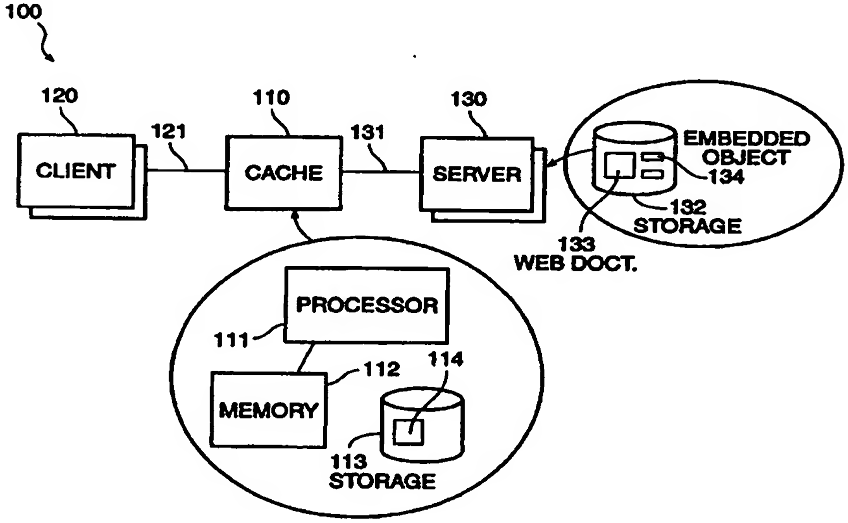
(81) Designated States: CA, CN, JP, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: SHARED CACHE PARSING AND PRE-FETCH

(57) Abstract

The invention provides a method and system for reducing latency in reviewing and presenting web documents to the user. A cache coupled to one or more web clients request web documents from web servers on behalf of those web clients and communicates those web documents to the web clients for display. The cache parses the web documents as they are received from the web server, identifies references to any embedded objects, and determines if those embedded objects are already maintained in the cache. If those embedded objects are not in the cache, the cache automatically pre-fetches those embedded objects from the web server without need for a command from the web client. The cache maintains a two-level memory including primary memory and secondary mass storage. At the time the web document is received, the cache determines if any embedded objects are maintained in the cache but are not in primary memory. If those embedded objects are not in primary memory, the cache automatically pre-loads those embedded objects from secondary mass storage to primary memory without need for a request from the web client. Web documents maintained in the cache are periodically refreshed, so as to assure those web documents are not stale. The invention is applied both to original requests to communicate web documents and their embedded objects from the web server to the web client, and to refresh requests to communicate web documents and their embedded objects from the web server to the cache.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania
AM	Armenia
AT	Austria
AU	Australia
AZ	Azerbaijan
BA	Bosnia and Herzegovina
BB	Barbados
BE	Belgium
BF	Burkina Faso
BG	Bulgaria
BJ	Benin
BR	Brazil
BY	Belarus
CA	Canada
CF	Central African Republic
CG	Congo
CH	Switzerland
CI	Côte d'Ivoire
CM	Cameroon
CN	China
CU	Cuba
CZ	Czech Republic
DE	Germany
DK	Denmark
EE	Estonia
ES	Spain
FI	Finland
FR	France
GA	Gabon
GB	United Kingdom
GE	Georgia
GH	Ghana
GN	Guinea
GR	Greece
HU	Hungary
IE	Ireland
IL	Israel
IS	Iceland
IT	Italy
JP	Japan
KE	Kenya
KG	Kyrgyzstan
KP	Democratic People's Republic of Korea
KR	Republic of Korea
KZ	Kazakstan
LC	Saint Lucia
LI	Liechtenstein
LK	Sri Lanka
LR	Liberia
LS	Lesotho
LT	Lithuania
LU	Luxembourg
LV	Latvia
MC	Monaco
MD	Republic of Moldova
MG	Madagascar
MK	The former Yugoslav Republic of Macedonia
ML	Mali
MN	Mongolia
MR	Mauritania
MW	Malawi
MX	Mexico
NE	Niger
NL	Netherlands
NO	Norway
NZ	New Zealand
PL	Poland
PT	Portugal
RO	Romania
RU	Russian Federation
SD	Sudan
SE	Sweden
SG	Singapore
SI	Slovenia
SK	Slovakia
SN	Senegal
SZ	Swaziland
TD	Chad
TG	Togo
TJ	Tajikistan
TM	Turkmenistan
TR	Turkey
TT	Trinidad and Tobago
UA	Ukraine
UG	Uganda
US	United States of America
UZ	Uzbekistan
VN	Viet Nam
YU	Yugoslavia
ZW	Zimbabwe

Shared Cache Parsing and Pre-fetch

Background of the Invention

1. *Field of the Invention*

This invention relates to caches.

2. *Related Art*

When presenting and reviewing data using a web browser or web client, that is, a client program for the web (the "World Wide Web") such as Netscape Corporation's "Navigator" product or Microsoft Corporation's Internet Explorer" product, it is desirable to present the data with as little delay as possible. If the user of the web client has to wait too long for the data to be displayed, this can lead to user dissatisfaction.

Some web clients access the web using a proxy cache, that is, a device for requesting web documents on behalf of the web client and for caching those web documents for possible later use. The proxy cache acts to reduce the amount of communication bandwidth used between the web client and web servers. A proxy cache can be shared by more than one web client, in which case it acts to reduce the total amount of communication bandwidth used between all of its web clients and web servers. One advantage of the proxy cache is that web documents stored in cache can be accessed more quickly than re-requesting those web documents from their originating web server.

One problem in the art is that a document requested by the web client (a "web document") can include, in addition to text and directions for display, embedded objects which are to be displayed with the web document. Embedded objects can include pictures, such as data in GIF or JPEG format, other multimedia data, such as animation, audio (such as streaming audio), movies, video (such as streaming video), program fragments, such as Java, Javascript, or ActiveX, or other web documents, such as when using frames. The web client must parse the web document to determine the embedded objects, and then request the embedded objects from the web server.

While using a proxy cache ameliorates this problem somewhat, the problem persists. If there are many embedded objects in the web document, it can take substantial time to identify, request, communicate, and display all of them. Parsing and requesting embedded objects by the web client is serial, and most web clients are set to request only a small number of embedded objects at a time. Web clients requesting embedded objects perform this task in parallel with rendering those objects for display, further slowing operation.

Moreover, known proxy caches use a two-level memory having a both primary memory and secondary mass storage. Even those embedded objects already maintained in the cache, and thus accessible by the web client without requesting them from the web server, can have been dropped out of the primary memory to secondary mass storage, possibly delaying communication of the embedded objects from the proxy cache to the web client and thus delaying display of those embedded objects to the user.

Accordingly, it would be advantageous to provide a method and system for reducing latency in reviewing and presenting web documents to the user. This advantage is achieved in a system in which web documents are parsed by a cache for references to embedded objects, and those embedded objects are pre-fetched from the web server or pre-loaded from secondary mass storage by the cache before they are requested by the web client.

Teachings of the art include (1) the known principle of computer science that devices work better when they are indifferent to the nature of the data they process, and (2) the known principle of client-server systems that it is advantageous to assign processing-intensive tasks to clients, rather than to servers, whenever possible. The invention is counter to the first teaching, as the cache alters its behavior in response to its parsing of the web documents it receives for communication to the client. The invention is also counter to the second teaching, as the cache takes on the additional processing tasks of parsing the web document for embedded objects and, if necessary, independently requesting those embedded objects from the web server.

Summary of the Invention

The invention provides a method and system for reducing latency in reviewing and presenting web documents to the user. A cache coupled to one or more web clients request web documents from web servers on behalf of those web clients and communicates those web documents to the web clients for display. The cache parses the web documents as they are received from the web server, identifies references to any embedded objects, and determines if those embedded objects are already maintained in the cache. If those embedded objects are not in the cache, the cache automatically pre-fetches those embedded objects from the web server without need for a command from the web client.

In a preferred embodiment, the cache maintains a two-level memory including primary memory and secondary mass storage. At the time the web document is received, the cache determines if any embedded objects are maintained in the cache but are not in primary memory.. If those embedded objects are not in primary memory, the cache automatically preloads those embedded objects from secondary mass storage to primary memory without need for a request from the web client.

In a preferred embodiment, web documents maintained in the cache are periodically refreshed, so as to assure those web documents are not "stale" (changed at the web server but not at the cache). The invention is applied both to original requests to communicate web documents and their embedded objects from the web server to the web client, and to refresh requests to communicate web documents and their embedded objects from the web server to the cache.

Brief Description of the Drawings

Figure 1 shows a block diagram of a system for shared cache parsing and prefetch.

Figure 2 shows a flow diagram of a method for shared cache parsing and prefetch.

Detailed Description of the Preferred Embodiment

In the following description, a preferred embodiment of the invention is described with regard to preferred process steps and data structures. Those skilled in the art would recognize after perusal of this application that embodiments of the invention can be implemented using one or more general purpose processors or special purpose processors or other circuits adapted to particular process steps and data structures described herein, and that implementation of the process steps and data structures described herein would not require undue experimentation or further invention.

Inventions disclosed herein can be used in conjunction with inventions disclosed in one or more of the following patent applications:

Provisional U.S. Application 60/048,986, filed June 9, 1997, in the name of inventors Michael Malcolm and Robert Zarnke, titled "Network Object Cache Engine," assigned to CacheFlow, Inc., attorney docket number CASH-001.

U.S. Application Serial No. 08/_______, filed this same day, in the name of inventors Michael Malcolm and Ian Telford, titled "Adaptive Active Cache Refresh," assigned to CacheFlow, Inc., attorney docket number CASH-003.

These applications are referred to herein as the "Cache Disclosures," and are hereby incorporated by reference as if fully set forth herein.

System Elements

Figure 1 shows a block diagram of a system for shared cache parsing and prefetch.

A system 100 includes a cache 110, at least one client device 120, and at least one server device 130. Each client device 120 is coupled to the cache 110 using a client communication path 121, such as a dial-up connection, a LAN (local area network), a WAN (wide area network), or some combination thereof. Similarly, each server device 130 is also coupled to the cache 110 using a server communication path 131, such as a dial-up connection, a LAN (local area network), a WAN (wide area network), or some combination thereof. In a preferred embodiment, the client communication path 121 includes a LAN, while the server communication path 131 includes a network of networks such as an internet or intranet.

As used herein , the terms "client" and "server" refer to a relationship between the client or server and the cache 110, not necessarily to particular physical devices. As used herein, one "client device" 120 or one "server device" 130 can comprise any of the following: (a) a single physical device capable of executing software which bears a client or server relationship to the cache 110; (b) a portion of a physical device, such as a software process or set of software processes capable of executing on one hardware device, which portion of the physical device bears a client or server relationship to the cache 110. The phrases "client device" 120 and "server device" 130 refer to such logical entities and not necessarily to particular individual physical devices.

The server device 130 includes memory or storage 132 having a web document 133, the web document 133 including references to at least one embedded object 134. In a preferred embodiment, the web document 133 can include text and directions for display. The embedded object 134 can include pictures such as data in GIF or JPEG format, other multimedia data, such as animation, audio (such as streaming audio), movies, video (such as streaming video), program fragments, such as Java, Javascript, or ActiveX, or other web documents, such as when using frames.

The cache 110 includes a processor 111, program and data memory 12, and mass storage 113. The cache 110 maintains a first set of web objects 114 in the memory 112 and a second set of web objects 114 in the storage 113. (Web objects 114 can comprise web documents 13 or embedded objects 134 or both.)

In a preferred embodiment, the cache 110 includes a cache device such as described in the Cache Disclosures defined herein, hereby incorporated by reference as if fully set forth therein.

The cache 110 receives requests from the client device 120 for a web object 114 and determines if that web object 114 is present at the cache 110, either in the memory 112 or in the storage 113. If the web object 114 is present in the memory 112, the cache 110 transmits the web object 114 to the client device 120 using the client communication path 121. If the web object 114 is present in the storage 113 but not in the memory 112, the cache 110 loads the web object 114 into the memory 112 from the storage 113, and proceeds as in the case when the web object 114 was originally present in the memory 112. If the web object 114 is not present in either the memory 112 or the storage 113, the cache 110 retrieves the web object 114 from the appropriate server device 130, places the web object 114 in the memory 112 and the storage 113, and proceeds as in the case when the web object 114 was originally present in the memory 112.

Due to the principle of locality of reference, it is expected that the cache 110 will achieve a substantial "hit rate," in which many requests from the client device 120 for web objects 114 will be for those web objects 114 already maintained by the cache 110, reducing the need for requests to the server device 130 using the server communication path 131.

The cache 110 parses each web object 114 as it is received from the server device 130, separately and in parallel to any web client program operating at the client device 120. If the web object 114 is a web document 133 that includes at least one reference to embedded objects 134, the cache 110 identifies those references and those embedded objects 134, and determines if those embedded objects 134 are already maintained in the cache 110, either in the memory 112 or the storage 113.

If those embedded objects 134 are not in the cache 110 at all, the cache 110n automatically, without need for a command from the web client , requests those embedded objects 134 from the server device 130.

The cache 110 has a relatively numerous set of connections to the server communication path 131, and so is able to request a relatively numerous set of embedded objects 134 in parallel from the server device 130. Moreover, the cache 110 parses the web document 133 and requests embedded objects 134 in parallel with the web client at the client device 120 also parsing the web document 133 and requesting embedded objects 134. The embedded objects 134 are available to the cache 110, and thus to the client device 120, much more quickly.

If those embedded objects 134 are maintained in the cache 110, but they are in the storage 113 and not in the memory 112, the cache 110 automatically, without need for a command from the web client, loads those embedded objects 134 from the storage 113 into the memory 112.

In a preferred embodiment, those web objects 114 maintained in the cache 110 are periodically refreshed, so as to assure those web objects 114 are not "stale" (changed at the server device 130 but not at the cache 110). To refresh web objects 114, the cache 110 selects one web object 114 for refresh and transmits a request to the server device 130 for that web object 114. The server device 130 can respond with a copy of the web object 114, or can respond with a message that the web object 114 has not changed since the most recent copy of the web object 114 was placed in the cache 110. If the web object 114 has in fact changed, the cache 110 proceeds as in the case when a client device 120 requested a new web object 114 not maintained in the cache 110 at all. If the web object 114 has in fact not changed, the cache 110 updates its information on the relative freshness of the web object 114, as further described in the Cache Disclosures.

Method of Operation

Figure 2 shows a flow diagram of a method for shared cache parsing and pre-fetch.

A method 200 includes a set of flow points to be noted, and steps to be executed, cooperatively by the system 100, including the cache 110, the client device 120, and the server device 130.

At flow point 210, the client device 120 is ready to request a web document 133 from the server device 130. For example, the web document 133 can comprise an HTML page having a set of embedded objects 134.

At a step 221, the client device 120 transmits a request for the web document 133, using the client communication path 121, to the cache 110.

At a step 222, the cache 110 determines if that web document 133 is located in the memory 112 at the cache 110. If so, the cache 110 proceeds with the step 225. Otherwise, the cache 110 proceeds with the step 223.

At a step 223, the cache 110 determines if that web document 13 is located in the storage 113 at the cache 110 (but not in the memory 112). If so, the cache 110 loads the web document 133 from the storage 113 into the memory 112, and proceeds with the step 225. Otherwise, the cache 110 proceeds with the step 224.

At a step 224, the cache 110 transmits a request to the server device 130 for the web document 133. The server device 130 receives the request and transmits the web document 133 to the cache 110. The cache 110 stores the web document 133 in the memory 112 and the storage 113 and proceeds with the step 225.

At a step 225, the cache 110 transmits the web document 133 to the client device 120 for display. In parallel, the cache 110 parses the web document 133 and determines if there are any references to embedded objets 134. If not, the cache 110 proceeds with the flow point 230. Otherwise, the cache proceeds with the step 226.

At a step 226, the cache 110 identifies the embedded documents 134 and repeats the steps 222 through 226 inclusive (including repeating this step 226) for each such embedded document 134. Web documents 133 in "frame" format can refer to embedded documents 134 that are themselves web documents 133 and themselves refer to embedded documents 134, and so on. There is no prospect of an infinite loop if web document 133 is self-referential because the cache 110 will simply discover at the second reference that the web document 133 is already maintained in the cache 110.

At a flow point 230, the web document 133 and all its embedded objects 134 have been transmitted to the client device 120 for display.

When the cache 110 refreshes a web object 114, the cache 110 performs the steps 222 through 226 inclusive (including repeating the step 226) for the web object 114 and for each identified embedded object 134 associated with the web object 114.

Alternative Embodiments

Although preferred embodiments are disclosed herein, many variations are possible which remain within the concept, scope, and spirit of the invention, and these variations would become clear to those skilled in the art after perusal of this application.

Claims

1. A method, including the steps of

receiving web documents at a shared cache from a web server or mass storage for communicating said web documents to a web client for display;

parsing said web documents for references to embedded objects;

determining if said embedded objects are already maintained in said shared cache;

conditionally pre-fetching said embedded objects from said web server in response to said step of determining, without need for a command from said web client.

2. A method as in claim 1, including the steps of

maintaining at said shared cache a two-level memory including primary memory and secondary mass storage;

locating said embedded objects in said shared cache but not in said primary memory;

conditionally pre-loading said embedded objects from said secondary mass storage into said primary memory in response to said step of locating, without need for a request from said web client.

3. A method as in claim 1, wherein said web documents include refresh copies of said web documents requested by said shared cache from said web server.

4. A system, including

a shared cache coupled to at least one web server and coupled to a plurality of web clients, said shared cache being capable of receiving requests for web documents from said web clients, requesting said web documents from said web server or mass storage, receiving said web documents from said web server or mass storage, and communicating said web documents to said web clients;

said shared cache including

means for parsing said web documents for references to embedded objects;

means for determining if said embedded objects are already maintained in said shared cache; and means for conditionally pre-fetching said embedded objects from said web server in response to said means for determining, without need for a command from said web client.

5. A system as in claim 4, including

A two-level memory at said shared cache, said two-level memory including primary memory and secondary mass storage;

means for locating said embedded objects in said shared cache but not in said primary memory;

means for conditionally pre-loading said embedded objects from said secondary mass storage into said primary memory in response to said means for locating, without need for a request from said web client.

6. A system as in claim 4, wherein said web documents include refresh copies of said web documents requested by said shared cache from said web server.

7. A shared cache, including

means for parsing said web documents, said web documents being received from a web server or from mass storage, for references to embedded objects;

means for determining if said embedded objects are already maintained in said shared cache; and

means for conditionally pre-fetching said embedded objects from said web server in response to said means for determining, without need for a command from said web client.

8. A cache as in claim 7, including

A two-level memory at said shared cache, said two-level memory including primary memory and secondary mass storage;

means for locating said embedded objects in said shared cache but not in said primary memory;

means for conditionally pre-loading said embedded objects from said secondary mass storage into said primary memory in response to said means for locating, without need for a request from said web client.

9. A cache as in claim 7, wherein said web documents include refresh copies of said web documents requested by said shared cache from said web server.

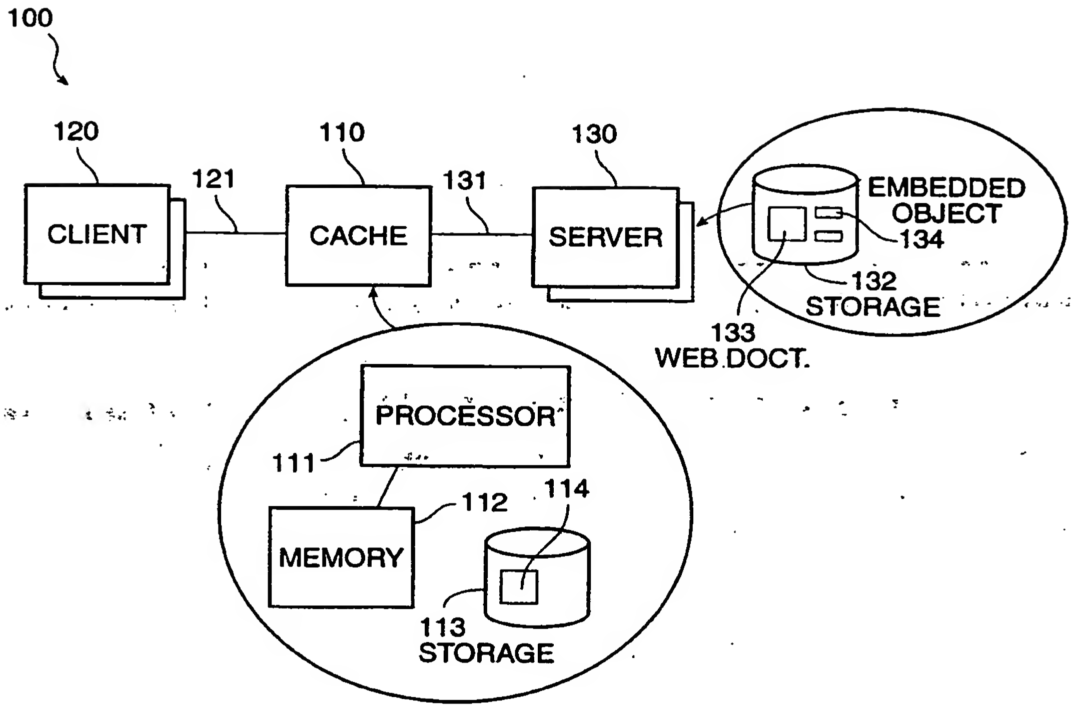

100
120
CLIENT
121
110
CACHE
131
130
SERVER
EMBEDDED OBJECT
134
132
STORAGE
133
WEB DOCT.
PROCESSOR
111
MEMORY
112
114
113
STORAGE

FIG. 1

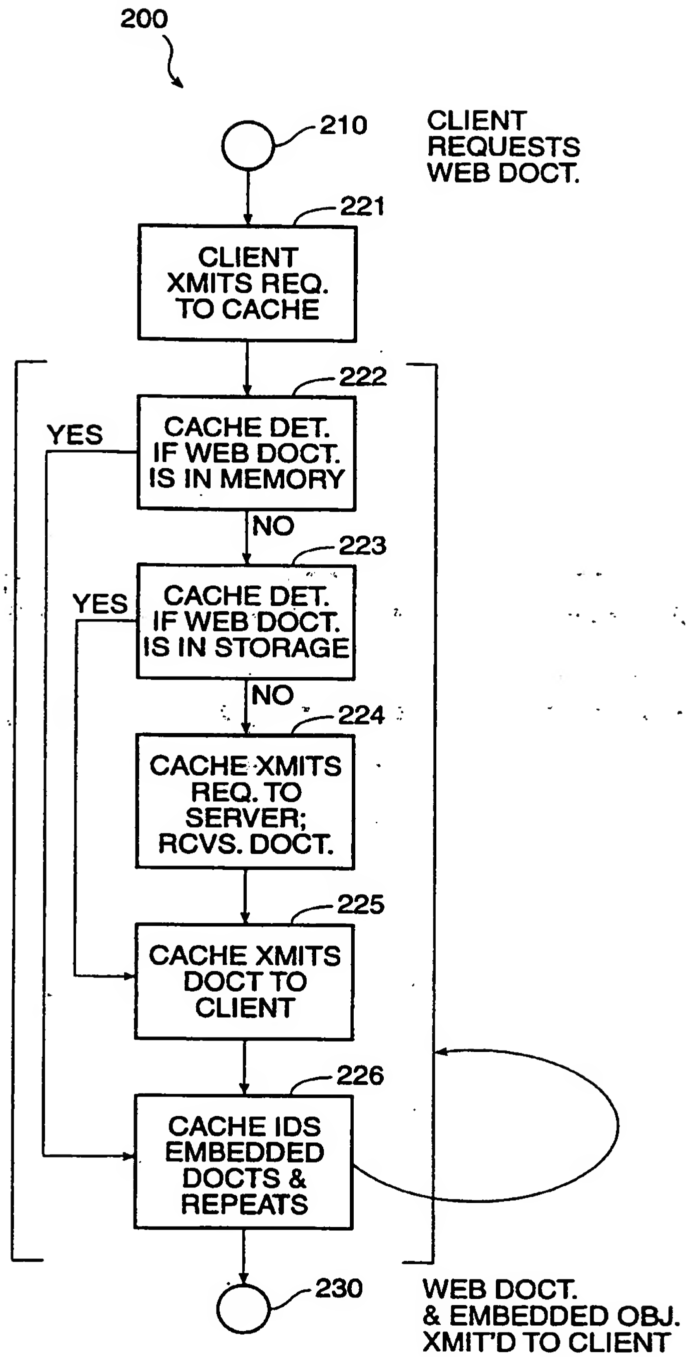

200
210
CLIENT
REQUESTS
WEB DOCT.
221
CLIENT
XMITS REQ.
TO CACHE
222
CACHE DET.
IF WEB DOCT.
IS IN MEMORY
YES
NO
223
CACHE DET.
IF WEB DOCT.
IS IN STORAGE
YES
NO
224
CACHE XMITS
REQ. TO
SERVER;
RCVS. DOCT.
225
CACHE XMITS
DOCT TO
CLIENT
226
CACHE IDS
EMBEDDED
DOCTS &
REPEATS
230
WEB DOCT.
& EMBEDDED OBJ.
XMIT'D TO CLIENT

FIG. 2

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 98/21008

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G06F17/30

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DIAS G. ET AL: "A Smart Internet Caching System" PROCEEDINGS OF THE INET'96 CONFERENCE, MONTREAL, CANADA, 24 - 28 June 1996, XP002086721 http://www.isoc.org/inet96/proceedings/a4/a4_3.htm see the whole document --- -/--	1,3,4,6, 7,9

☒ Further documents are listed in the continuation of box C.

□ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search 4 December 1998	Date of mailing of the international search report 21/12/1998
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Fournier, C

1

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 98/21008

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	WANG Z ET AL: "Prefetching in World Wide Web" IEEE GLOBECOM 1996. COMMUNICATIONS: THE KEY TO GLOBAL PROSPERITY. GLOBAL INTERNET'96. CONFERENCE RECORD (CAT. NO.96CH35942), IEEE GLOBECOM 1996. COMMUNICATIONS: THE KEY TO GLOBAL PROSPERITY. GLOBAL INTERNET'96. CONFERENCE RECORD, LONDON, UK, 18-22 NO, pages 28-32, XP002086567 ISBN 0-7803-3336-5, 1996, New York, NY, USA, IEEE, USA see page 30, left-hand column, line 44 - page 31, right-hand column, paragraph 7 ---	1,3,4,6, 7,9
A	CHINEN K. ET AL: "An interactive Prefetching Proxy Server for Improvement of WWW Latency" PROCEEDINGS OF THE INET'97 CONFERENCE, KUALA LUMPUR, MALAYSIA, 24 - 27 June 1997, XP002086569 http://www.isoc.org/INET97/proceedings/a1/a1_3.htm see the whole document -----	1,3,7

1